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EP 0346859 A2 WO 93/08540 A1 US 5287089 A
US 5018208 A

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(54) Haptic computer input device eg for virtual reality

(57) Typically for use in Virtual Reality computer software applications, the invention provides a hand-held haptic computer input device comprising a body (1) grippable in the palm of the hand of a user and a front panel (4) contactable by the fingers of the user at points A, B, C, D. The outer membrane of panel (4) is resiliently flexible and at each of points A to D covers a respective pressure transducer actuator fabricated from a resiliently flexible or elastomeric material. Each actuator is arranged so as at least in part to be flexed or compressed relative to the body (1) by pressure applied by the appropriate digit of the user. The arrangement provides that deformation of an actuator by movement of the appropriate digit and the resultant electrical transducer output are both generally in proportion to the magnitude of the pressure applied.

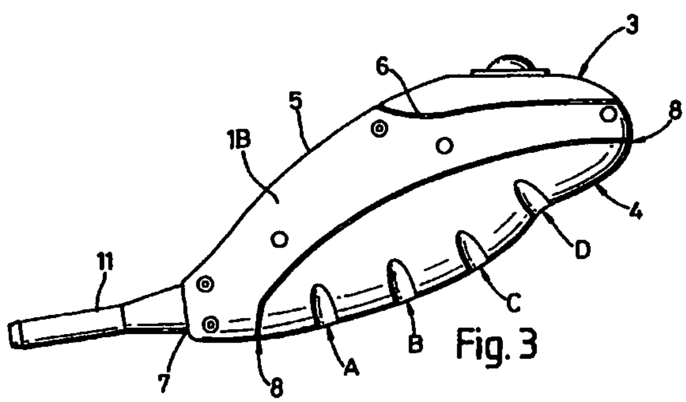

Fig. 3

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

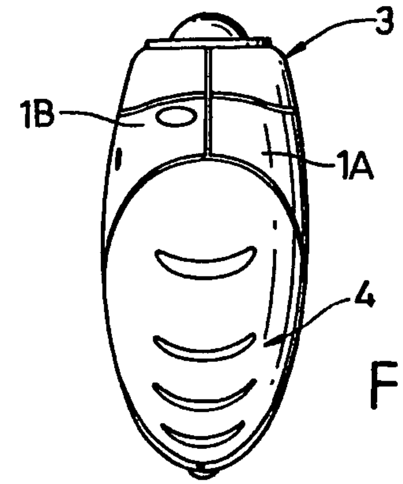

Fig. 1

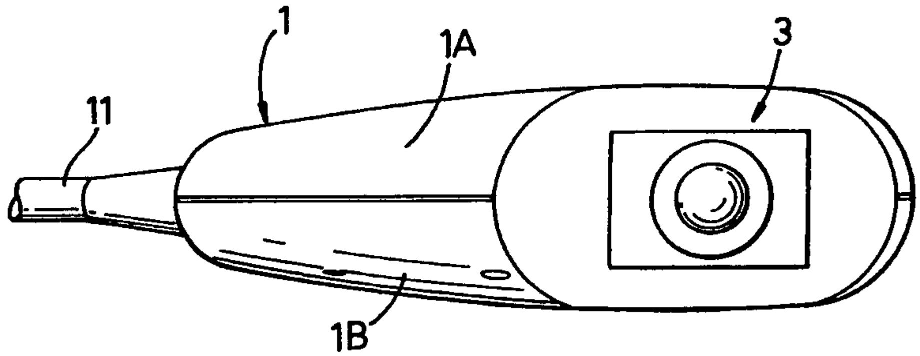

Fig. 2

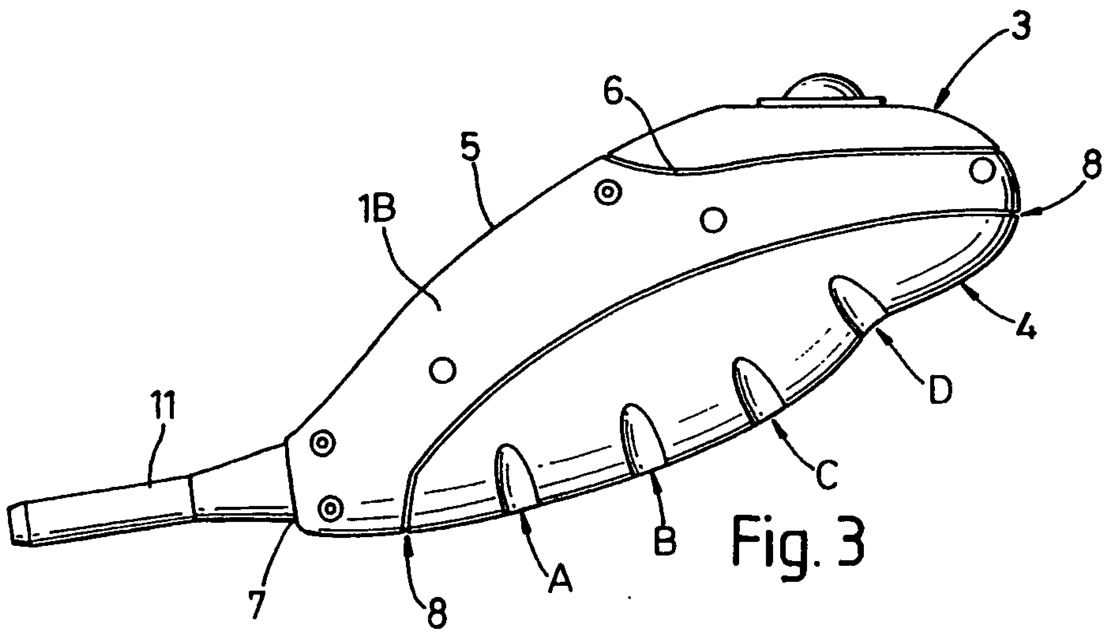

Fig. 3

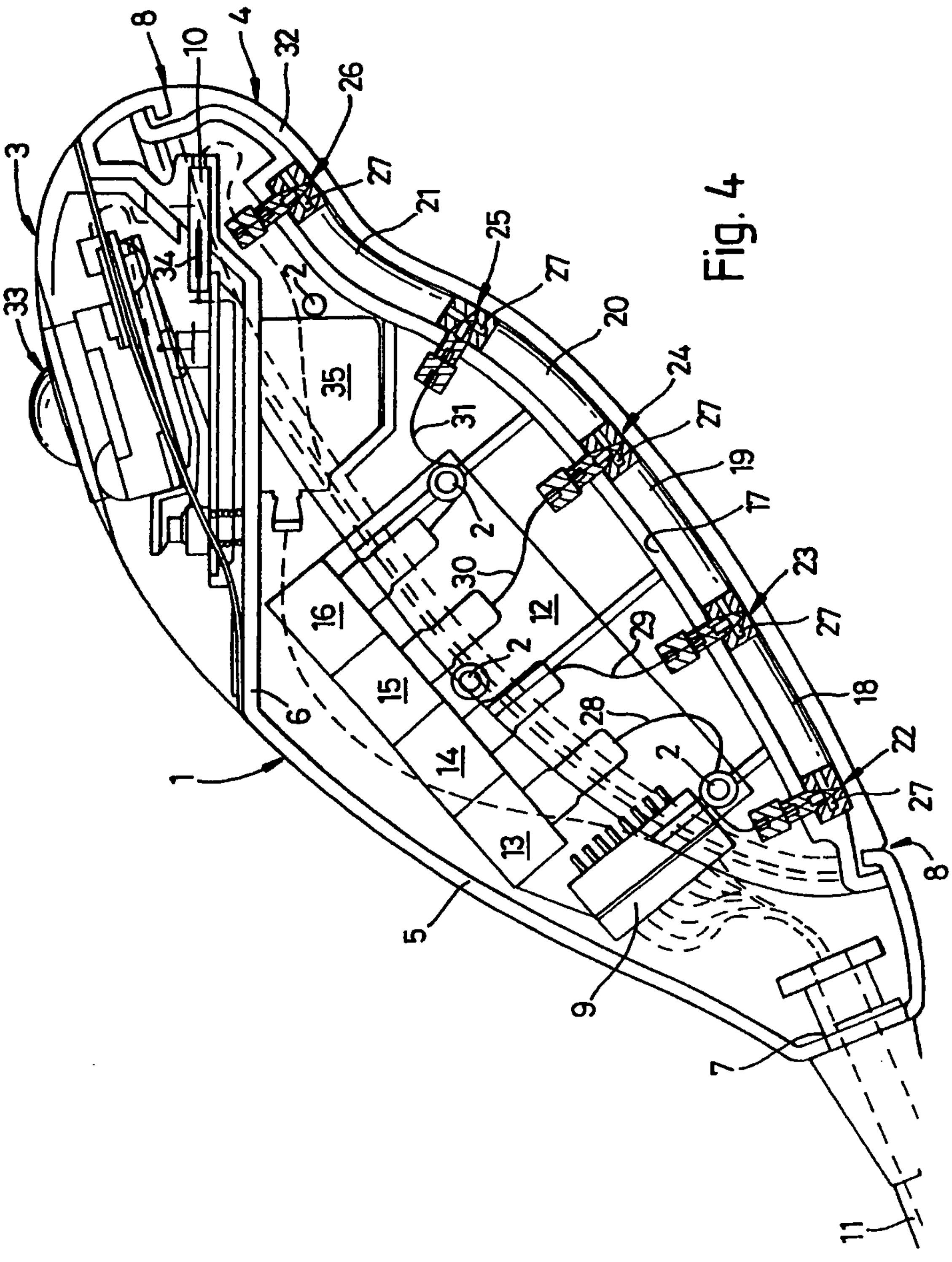

Fig. 4

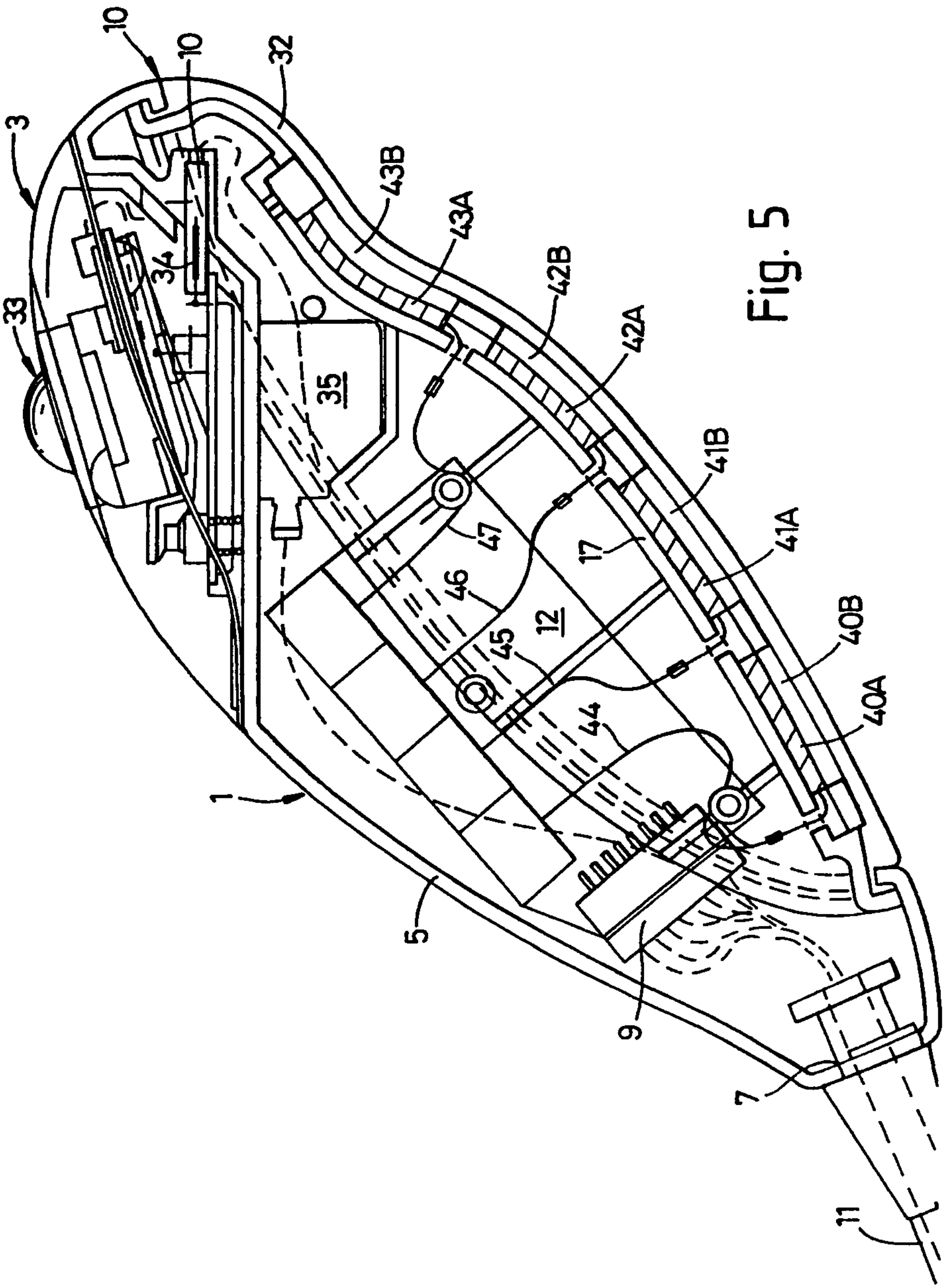
10
10
32
3
33
34
43B
43A
42B
42A
35
41B
41A
17
47
46
12
45
40B
40A
44
1
5
9
7
11

Fig. 5

HAPTIC COMPUTER INPUT DEVICE

This invention relates to computer input devices generally and more particularly but not exclusively to a haptic computer input device adapted to be gripped in the palm of a hand of a user and having 'data' input means operable by the fingers and/or thumb of the hand typically for use in conjunction with virtual reality computer software applications.

In the field of virtual reality computer simulation the increased resolution of graphics in model space, i.e. that viewed in the virtual world, which can be manipulated in real time has resulted in a proliferation of man-machine control interfaces. Such interfaces are typically known as HCI's - Human Computer Interfaces. For manipulating the caricature of a hand in model space hitherto it has been suggested that an HCI in the form of a exo-skeletal glove be used. Such gloves require sensors to determine the relative digit position as well as spatial position means to monitor the position of the hand relative to a fixed datum.

Spatial position sensing means can be provided by transmitter or receiver means of known type. Typically, in glove type HCI's a housing for these means could be provided disposed adjacent the back of the hand. If wrist flexure is also being measured then these means could alternatively be disposed adjacent the wrist.

The remainder of the glove houses a multiplicity of input sensors to monitor finger and/or joint movement such as those which rely on hand manipulation affecting the transmission path between LED's and associated photodetectors. Examples of such sensors are described in European Patent Specification No 0 211 984. Another suggested way of measuring finger movement by joint flexure is to fit the glove with tendon like linkages between fixings one side of a given joint and a respective strain gauge or rectilinear operable transducer (e.g. LVDT - Linear Variable Differential Transducers) anchored at the other side of said joint. In yet another suggested way the strain gauges form part of elongate tendrils each attached over a joint of the hand to form a 'goniometer' adapted to measure

joint deflection.

All of the aforementioned glove type 'data' input devices are both bulky and generally difficult to don and doff. Also, their use prohibits free movement and flexure of the hand resulting in a somewhat restricted feel to the user. This is likely to impact on the perceived realism of the manipulation of a hand-shaped or grabber-shaped cursor in model space. To enhance realism it is often necessary to include pressure feedback means in the glove to provide the user with some degree of concrete feel when an object in model space is contacted by the virtual hand/cursor. Typically, feedback can be provided by electrical solenoids or by inflatable bladders disposed in the glove along the underside of the fingers, for example.

The inventor has appreciated that devices of the aforementioned type rely on flexure of the hand to be mimicked directly in model space. However, it is well known that the brain is able readily to observe and comprehend hand manipulation when translated into a different form of motion, for example as may occur in the operation of a joystick or steering wheel. It is this human ability to provide visual feedback which the inventor utilises in the subject invention.

It is an object of the invention to provide computer 'data' input means associated with the hand of a user which overcomes some of the disadvantages of the aforementioned glove type constructions and which utilises the innate human ability to accept the translation of one type of hand manipulation into another type of motion in 'reality', i.e. in virtual reality applications said another type of motion may be visible in model space and perceived to be real.

According to a first aspect of the invention a hand-held haptic computer input device comprises a body grippable in the palm of the hand of a user, a pressure transducer attached to the body and a manually operable actuator for the pressure transducer fabricated from a resiliently flexible or elastomeric material, the actuator being arranged so as at least in part to be flexed or compressed relative to the body by pressure applied by a digit of a user gripping the body, and the arrangement providing that

deformation of the actuator by movement of the digit and the resultant electrical transducer output are both generally in proportion to the magnitude of the pressure applied. The actuator may be integral with the pressure transducer or may be separate from and disposed adjacent the pressure transducer.

Preferably, the actuator is provided by a fluid filled enclosure communicating with the pressure transducer and may be a section of resilient tubing attached to one side of the body.

Typically, the body is provided by a housing having a rigid back wall adapted to seat against the palm of a user and a rigid front wall adapted to extend behind the fingers of the user, with the front wall having a recessed formation in which the section of tubing can seat and the housing further comprising a flexible outer membrane adapted to extend over at least a part of the front wall to cover the tubing sidewall.

The pressure transducer may comprise a force sensing resistor having a polymer surface coated with interdigitating electrodes and a semiconductor coated polymer substrate. Alternatively, the pressure transducer may be a pneumatic/hydraulic pressure transducer and one end of the tubing is connected so that its interior communicates with the transducer and the other end is plugged. And the transducer may be retained within the housing adjacent the back wall, said one end of the section of tubing is connected to a pipe connector which extends from the chamber of the housing into the recessed formation, and a generally inextensible, i.e. non-inflatable, section of pipe extends between the connector and the transducer. The said pipe connector may be in the form of a T-joint providing a right-angled fluid passageway and a blind limb which can be used to plug one end of another section of tubing.

Preferably, a plurality of transducers and associated actuators are provided with each actuator being flexible or compressible by a respective digit of the user. A thumb operated electrical switch and/or a thumb operated track-ball may be attached to the body. The body may comprise a main base portion which houses said transducer(s) and actuator(s) and a

plug detachable upper crown portion housing said switch and/or track-ball. The body may further comprise a transmitter or a receiver of spatial position sensing means. And a retaining strap may be attached to the body which is adapted to extend around the back of the hand of a user gripping the body.
Pressure feedback means associated with the or each actuator to provide when desired increased resistance to compressibility or flexibility may be provided.

According to a second aspect of the invention a virtual reality computer system comprises a CPU, a video display and/or head mounted display and haptic device in accordance with the aforementioned first aspect of the invention, wherein in use proportionate compression or flexure of a given one of the actuators is exhibited in the 'virtual world' as progressive movement of the corresponding part of a cursor displayed in the form of a representation of a human hand or grabber so that slight compression or flexure results in slight relative movement and maximum compression or flexure results in maximum relative movement of said representation.

Embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings in which:-

Figure 1 is a front view of a haptic computer input device in accordance with the invention;

Figure 2 is a top view of the haptic input device shown in Figure 1;

Figure 3 is a right hand side view of the haptic input device shown in Figure 1;

Figure 4 illustrates diagrammatically the internal structure of the haptic input device oriented as shown in Figure 3 and in accordance with a first embodiment of the invention, and

Figure 5 is a view similar to that of Figure 4 wherein the haptic input device is shown diagrammatically in accordance with a second embodiment of the invention.

Both the illustrated embodiments are each in the form of a haptic computer input device adapted to be gripped in the palm of the hand of a user and having 'data' input means operable by the fingers and thumb of the hand. The embodiments, as shown in Figures 1 to 3, each comprise a body having a moulded plastics housing 1 in two-parts 1A, 1B fixed together by means of pegs 2 (see Figure 4). The body further comprises a plug detachable crown portion 3 and front panel or portion 4. The housing 1 has a back wall 5 which seats in the palm, a crown face 6 against which the portion 3 seats, cable connection port 7 and retention formations generally denoted 8 (shown in detail in Figure 4).

In the first embodiment, the internal structure of which is illustrated in Figure 4, Electrical connector block 9 is fixed within the housing 1. Connector block 10 is aligned with crown face 6 when front portion 4 is fixed relative to the housing 1. Block 9 is sandwiched between formations on three of the pegs 2 when the two parts 1A,1B of the housing are fixed together. A cable loom 11 extends through port 7 to provide electrical connection between the blocks 9,10 and associated computer hardware (not shown). A circuit board 12 plugged into connector block 9 has mounted thereon four pressure transducers 13,14,15,16 and associated electrical circuitry. Each of these transducers, typically being pneumatic or hydraulic pressure transducers, is adapted to provide an electrical output in proportion to the fluid pressure to which it is subjected. Typically and desirably, this output is linear, i.e. proportional to the input pressure, although the output may not always be so. Appropriate calibration of the computer hardware will facilitate the use of transducers having a non-linear output.

A front face to the housing 1 is provided by portion 4 which is adapted to extend behind the fingers of a user and which at its upper and lower extent is held captive by the respective formation 8 when the two parts of the housing 1 are fixed together. The portion 4 has a rigid wall

17 having a profile to facilitate being clamped by the fingers of the user. This wall 17 defines an elongate recess into which sections 18,19,20,21 of resilient tubing are seated. A plurality of T-joint pipe connectors 22,23,24,25,26 extend through the wall 17 with their respective T crossbar lying lengthways in the recess.

Each T-joint pipe connector 22 to 26 has a blind limb 27 of the T crossbar with the remaining limbs providing a respective right-angled fluid passageway. The section 18 of tubing corresponding to the little finger is attached to connector 22 at one end and plugged by the blind limb 27 of connector 23 at the other. Similarly section 19 extends between connectors 23,24; section 20 extends between connectors 24,25, and section 21 extends between connectors 25,26. It will be appreciated that the blind limb of connector 22 and the fluid passageway of connector 26 are redundant. Consequently, connectors 22 and 26 could be replaced respectively by a more appropriate pipe connector and plug.

Relatively inextensible pipes 28,29,30,31 extend respectively between connectors 22,23,24,25 and transducers 13,14,15,16. Consequently, the interior chambers of tubing sections 18 to 21 communicate with an associated transducer 13 to 16 and the output from each of these transducers relates to the pressure applied to the corresponding section of tubing. Thus, sections 18 to 21 are each an actuator for the associated transducer 13 to 16.

Front portion 4 of the body further comprises a flexible membrane cover 32 extending generally parallel to the wall 17. The membrane 32 extends over and encloses the sections of tubing 18 to 21 and pipe connectors 22 to 26. The membrane 32 is sufficiently flexible to permit compression of the sections of tubing 18,19,20,21 by the light application of pressure by fingers of the user at positions A,B,C,D respectively shown on Figure 3.

The T-joint connectors 22 to 26 are generally rigid, consequently the membrane 32 is only compressible therebetween thus defining locations/positions A,B,C,D for the fingers of the user. Suitably, the

body is constructed so that it will accommodate use by people of different hand size and finger reach. If desired the membrane 32 may be moulded so as to provide indentations corresponding to locations A,B,C and D to enable ready location of the fingers of the user.

Crown portion 3 of the body is suitably fitted with a track-ball 33 which internally of the portion 3 is provided with a connector 34 plugable into the connector block 10 of the main housing 1. Additional retention means may be provided to ensure that the crown portion 3 remains fixed to the housing 1. It will be appreciated that interchangeable crown portions 3 may be provided. For example, a crown portion having switches in place of or together with the track-ball 33 could be used. These are disclosed in detail in our co-pending UK Patent Application filed this date with the title "Versatile Thumb-Controllable Haptic Computer Input Device"

In addition to the aforedescribed 'data' input means, the housing 1 is provided with retention means for a position sensor 35 which may conveniently be the transmitter or receiver of a position sensing device. Thus, the computer hardware receives input from the fingers and thumb of the user whilst being able to monitor the relative spatial position of the hand.

The internal structure of the second embodiment, which is illustrated in Figure 5, is generally similar to that of the first embodiment (shown in Figure 4) and like numerals denote like or functionally similar parts. In this embodiment the aforedescribed hydraulic/pneumatic pressure transducers 13 to 16, sections of tubing 18 to 21 and associated connecting/fixing means of the first embodiment are replaced by a different transducer technology, namely force sensing resistor (FSR) technology.

Typically, such technology utilises FSR's each in the form of a two-ply polymer laminate in which an outer polymer surface layer coated with interdigitating electrodes is attached to a semiconductor coated polymer substrate. The resistance of the substrate ply is dependent on the pressure applied to the polymer surface layer.

In the second embodiment FSR's are diagrammatically illustrated in figure 5 and numbered (40A,40B), (41A,41B), (42A,42B) and (43A,43B) - where 'A' denotes the substrate and 'B' denotes the generally resiliently flexible polymer surface layer. It will be appreciated that such FSR's can be considerably thinner than illustrated herein. Consequently, in the construction illustrated in Figure 5 it would be possible to interpose between the elastomeric membrane 32 and thinner FSR's actuators each in the form of a foam or elastomeric element, or a section of small bore resiliently compressible tubing.

The FSR's 40,41,42,43 are connected respectively by way of electrical wiring 44,45,46,47 to the electrical circuit board 12 and via cable loom 11 to the computer hardware. The arrangement enables the resistance change of the FSR's under applied pressure to be measured and calibrated. With appropriate circuitry on circuit board 12 each FSR can function as a separate pressure transducer. Resilience of FSR's themselves provides that finger movement will be in proportion to applied pressure whilst the provision of the elastomeric membrane 32 enables that movement to be greater than if pressure were applied directly to the FSR's. In this embodiment the actuators of the FSR's can be viewed as either the integral surface layers 40B,41B,42B,43B respectively, the respective overlying regions of the membrane 32, or a combination of both.

Functionally, the two aforedescribed embodiments are essentially the same. In both cases pressure applied to the membrane 32 at positions A,B,C,D (shown in Figure 3) will result in a corresponding electrical 'output' respectively from transducers 18 to 21 or 40 to 43 and movement of membrane 32 in proportion to the pressure applied.

The aforedescribed embodiments are particularly useful when used in association with a virtual reality computer programme application in which a cursor in the shape of a hand or grabber is controlled in model space. The cursor can be provided with four digits controllable by the user gripping the housing 1 with each digit corresponding to a respective one of the user's fingers, i.e. controlled by actuators at or associated with positions A,B,C,D.

Applying a given pressure to one of the positions A,B,C,D will result in an electrical signal from the associated transducer which in turn leads to corresponding movement of the associated digit in model space. An increased pressure would result in greater movement and conversely a lighter pressure would result in less movement. The user advantageously is able to sense a certain degree of feedback from the actual movement of their own digits as well as the pressure applied.

Obviously, the grip will vary from user to user and consequently it would be possible to introduce a bias into the circuitry so that the input device could be customised for different users. For, example in embodiments using a compressible tubing, or other like bladder, means could be provided for increasing the pressure within the tubing so that a greater pressure is needed to effect compression thereof. Also, it may be desirable to introduce feedback means to alert the user to contact of digits of the cursor with an object in model space.

CLAIMS:

1. A hand-held haptic computer input device comprising a body grippable in the palm of the hand of a user, a pressure transducer attached to the body and a manually operable actuator for the pressure transducer fabricated from a resiliently flexible or elastomeric material, the actuator being arranged so as at least in part to be flexed or compressed relative to the body by pressure applied by a digit of a user gripping the body, and the arrangement providing that deformation of the actuator by movement of the digit and the resultant electrical transducer output are both generally in proportion to the magnitude of the pressure applied.

2. A haptic device in accordance with claim 1, wherein the actuator is integral with the pressure transducer.

3. A haptic device in accordance with claim 1, wherein the actuator is separate from and disposed adjacent the pressure transducer.

4. A haptic device in accordance with claim 1, wherein the actuator is provided by a fluid filled enclosure communicating with the pressure transducer.

5. A haptic device in accordance with claim 3 or claim 4, wherein the actuator is a section of resilient tubing attached to one side of the body.

6. A haptic device in accordance with claim 5, wherein the body is provided by a housing having a rigid back wall adapted to seat against the palm of a user and a rigid front wall adapted to extend behind the fingers of the user, with the front wall having a recessed formation in which the section of tubing can seat and the housing further comprising a flexible outer membrane adapted to extend over at least a part of the front wall to cover the tubing sidewall.

7. A haptic device in accordance with any one of the preceding claims, wherein the pressure transducer comprises a force sensing resistor having a polymer surface coated with interdigitating electrodes and a semiconductor

coated polymer substrate.

8. A haptic device in accordance with claim 6, wherein the pressure transducer is a pneumatic/hydraulic pressure transducer and one end of the tubing is connected so that its interior communicates with the transducer and the other end is plugged.

9. A haptic device in accordance with claim 8, wherein the transducer is retained within the housing adjacent the back wall, said one end of the section of tubing is connected to a pipe connector which extends from the chamber of the housing into the recessed formation, and a generally inextensible section of pipe extends between the connector and the transducer.

10. A haptic device in accordance with claim 9, wherein the pipe connector is in the form of a T-joint providing a right-angled fluid passageway and a blind limb which can be used to plug one end of another section of tubing.

11. A haptic device in accordance with any one of the preceding claims, wherein a plurality of transducers and associated actuators are provided with each actuator being flexible or compressible by a respective digit of the user.

12. A haptic device in accordance with any one of the preceding claims, further comprising a thumb operated electrical switch and/or a thumb operated track-ball attached to the body.

13. A haptic device in accordance with claim 13, wherein the body comprises a main base portion which houses said transducer(s) and actuator(s) and a plug detachable upper crown portion housing said switch and/or track-ball.

15. A haptic device in accordance with any one of the preceding claims, wherein the body further comprises a transmitter or a receiver of spatial position sensing means.

16. A haptic device in accordance with any one of the preceding claims, wherein a retaining strap is attached to the body which is adapted to extend around the back of the hand of a user gripping the body.

17. A haptic device in accordance with any one of the preceding claims, further comprising pressure feedback means associated with the or each actuator to provide when desired increased resistance to compressibility or flexibility.

18. A virtual reality computer system comprising a CPU, a video display and/or head mounted display and a haptic device in accordance with any one of claims 11 to 17, wherein in use proportionate compression or flexure of a given one of the actuators is exhibited in the 'virtual world' as progressive movement of the corresponding part of a cursor displayed in the form of a representation of a human hand or grabber so that slight compression or flexure results in slight relatûve movement and maximum compression or flexure results in maximum relative movement of said representation.

19. A hand-held haptic computer input device for virtual reality applications substantially as hereinbefore described and as illustrated in Figures 1,2,3 and 4, or Figures 1,2,3 and 5 of the accompanying drawings.

Patents Act 1977 **Examiner's report to the Comptroller under Section 17** -13- **.he Search report)**	Application number GB 9418487.6
Relevant Technical Fields (i) UK Cl (Ed.M) F2Y (YTA); G3N (NGE3B) (ii) Int Cl (Ed.5) G06F 3/00; G06K 11/18; H01H 9/02	Search Examiner JOHN TWIN Date of completion of Search 28 NOVEMBER 1994
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE DATABASE: WPI	Documents considered relevant following a search in respect of Claims :- 1-19

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
Y	EP 346859 A2	(WANG LABORATORIES)	1
X,Y	WO 93/08540 A1	(SRI INTERNATIONAL)	1 at least
X,Y	US 5287089	(PARSONS)	1 at least
X,Y	US 5018208	(GLADSTONE)	1 at least

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